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The Effect of Preformed Plasmas on Relativistic Electron Acceleration

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Disclaimer

The Effect of Preformed Plasmas on Relativistic Electron Acceleration

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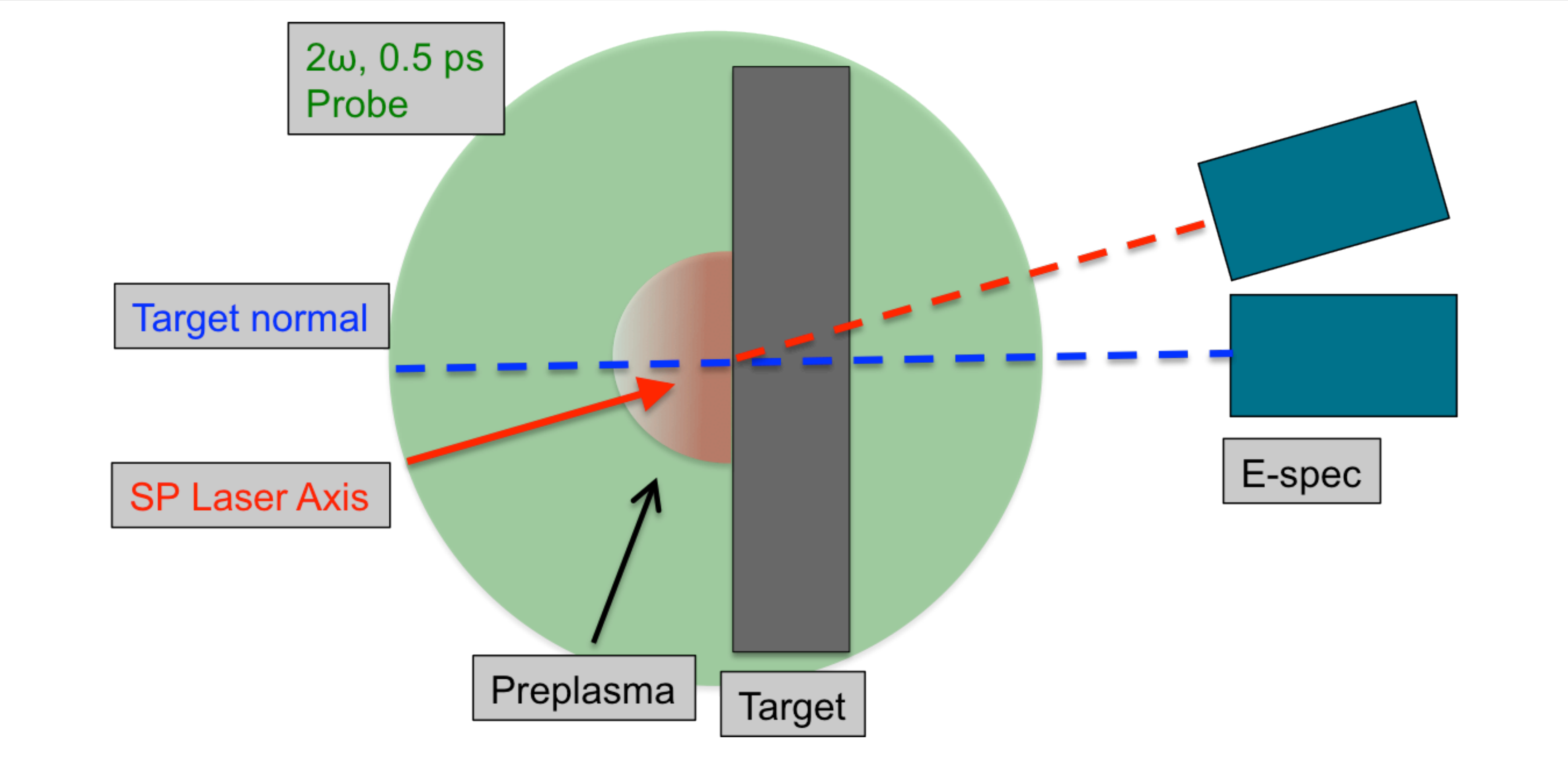
There haven't been systematic experimental studies to correlate preplasmas to relativistic electrons

- Two Experimental Studies
  - Optical Interferometer and Electron Spectrometers
  - Prepulse measurement
  - 2ω Short Pulse laser with 1ω Long Pulse laser
  - 1ω Short Pulse laser
- HYDRA Simulation
- Relativistic Electron Directionality vs. Scalelength

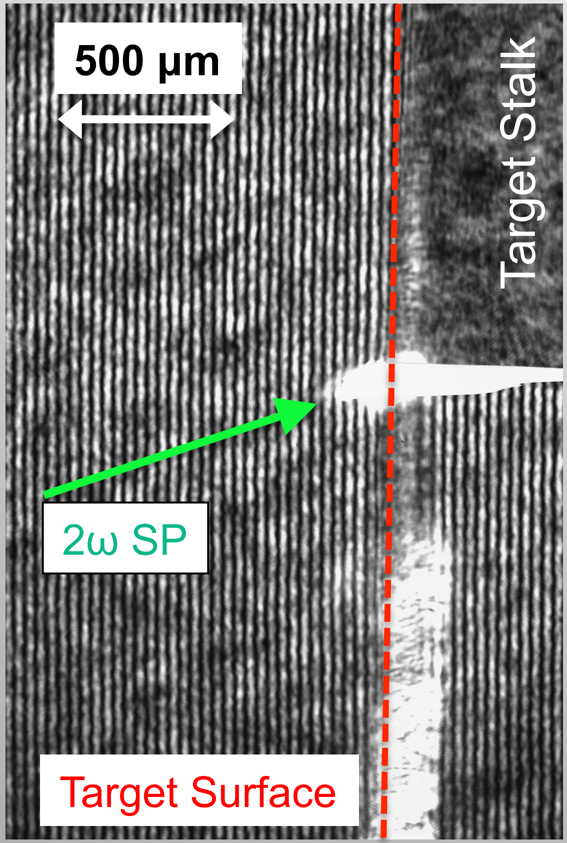
Plasma density and electron spectra are simultaneously measured.

Laser, Target and Diagnostics orientation (top-down view)

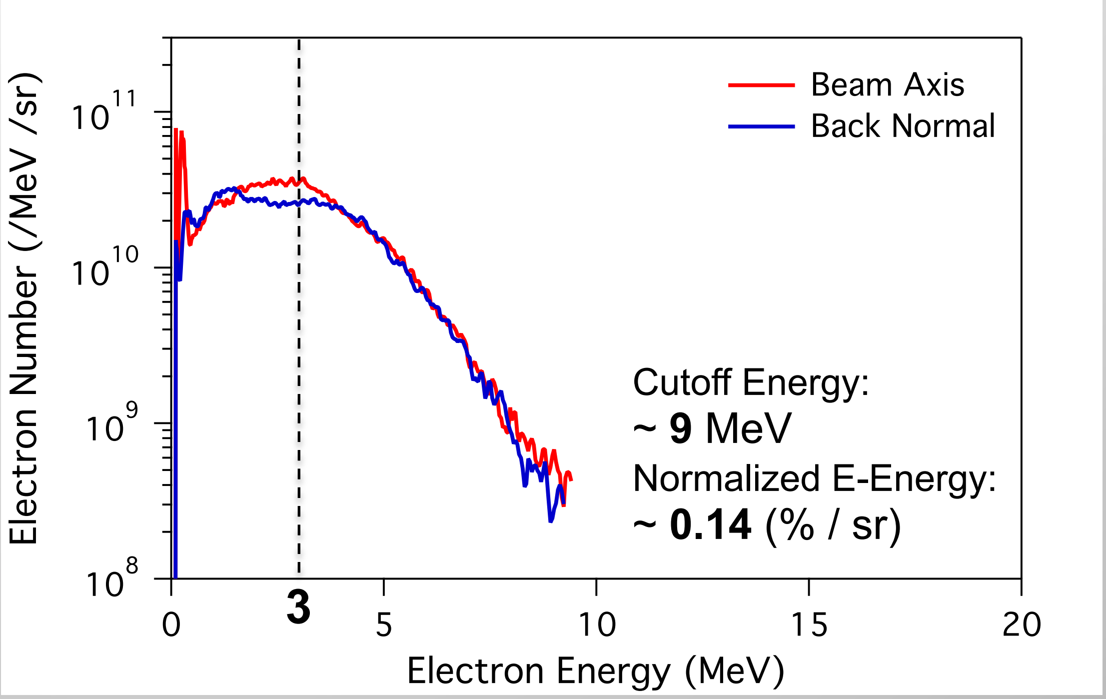


2ω Short Pulse laser has better intensity contrast than 1ω Short Pulse laser (10^9 vs. 10^7).

2ω Interferogram negligible prepulse on Al taken 100 ps prior to SP



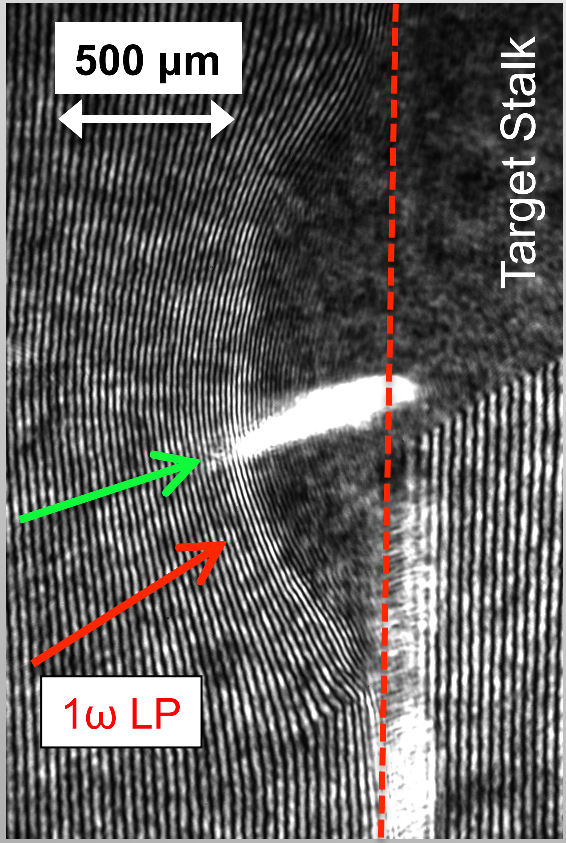
Electron spectra : No LP, 32.5J SP energy



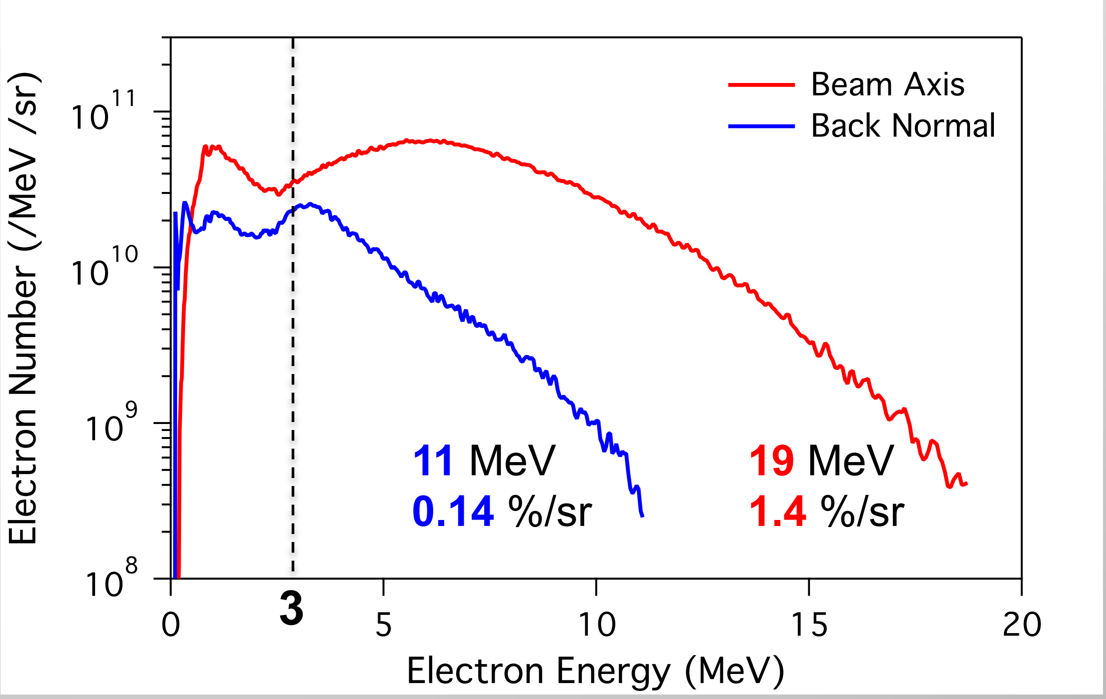
Electron Spectra at beam axis and target back normal show near identical characteristics without 1ω LP prepulse.

Long Pulse Prepulse injection affects electrons along the beam axis more than the back normal.

2ω Interferogram
1ω, 51 J prepulse on Al
taken 100 ps prior to SP



Electron Spectra : 51J LP Energy, 35.6J SP Energy



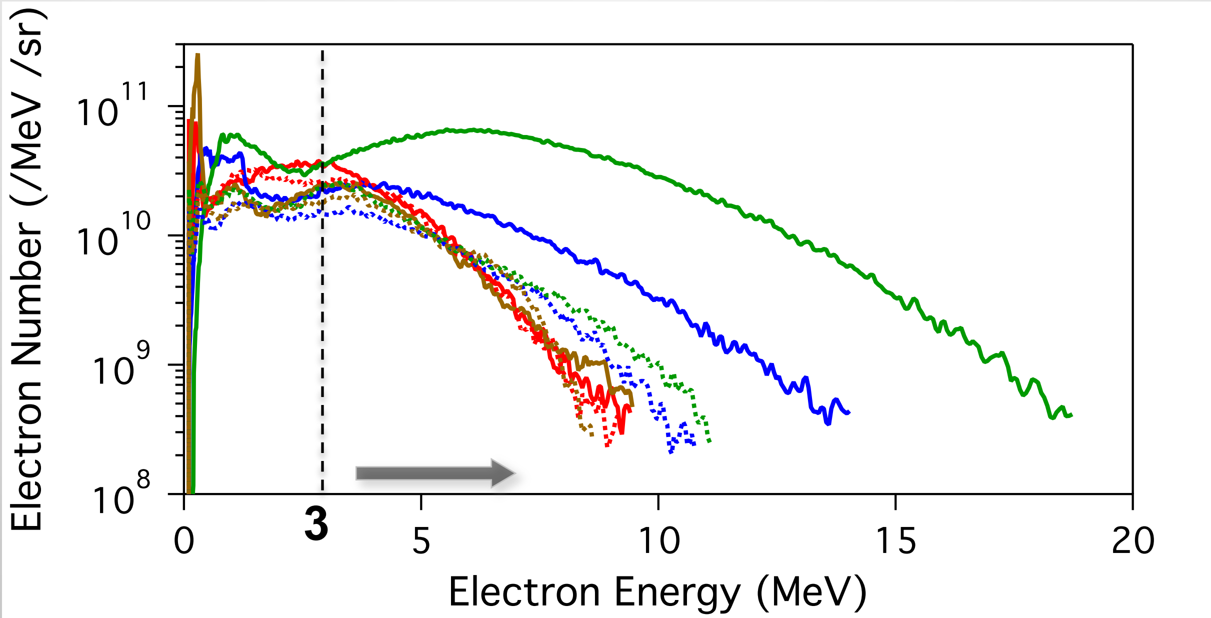
Change in electrons along the SP axis.

9 MeV ➔ 19 MeV

0.14 % / sr ➔ 1.4 % / sr

≥ 3 MeV Electron Energy Ratio (E_{BA}/E_{TBN}) is used to describe the electron beam directionality.

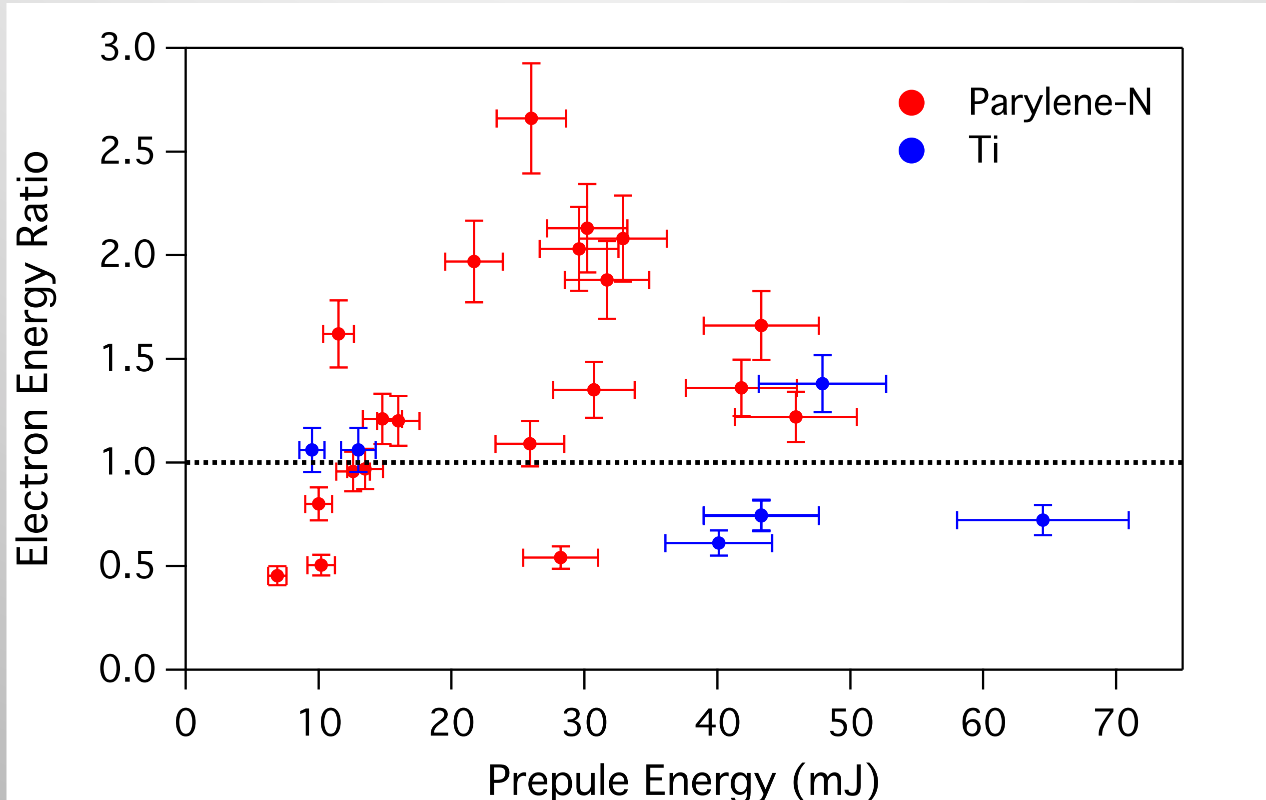
Electrons spectra at three LP energies, 0, 28, and 51 J



Prepulse Energy	0 J	28 J	51 J
Ratio (±10%)	**1.1**	**2.5**	**10.0**
Divergence (FWHM)	**102°**	**33°**	**21°**

1ω experiment result showed similar electron beam directionality.

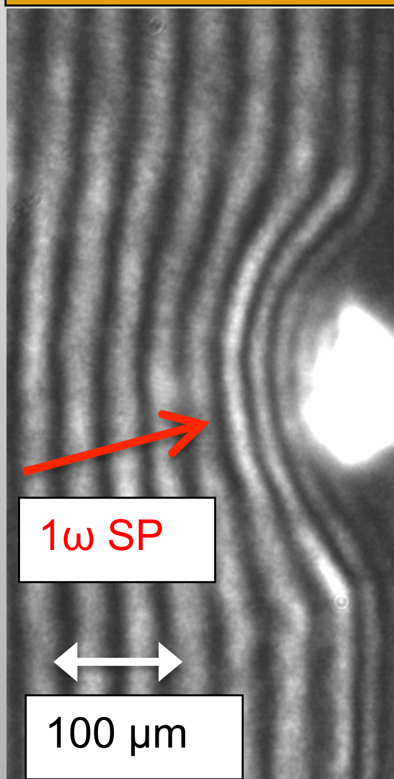
E-beam directionality vs. Prepulse energy (mJ)



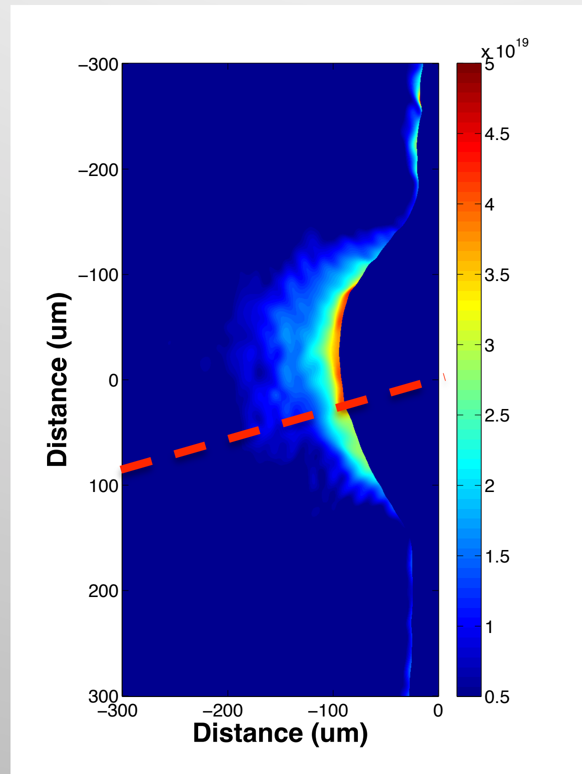
Various Targets ➔ Hydro-dynamic simulation is needed

HYDRA simulation results match experimental 1-D profiles in low density regions.

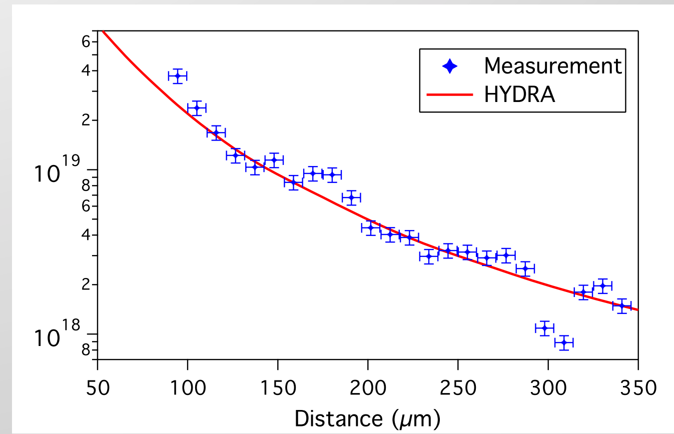
2ω Interferogram
32 mJ prepulse
30 ps prior to SP



2-D density profile
(FT & 'Onion-Peeling')*,**



1-D density profiles
Measurement vs. HYDRA



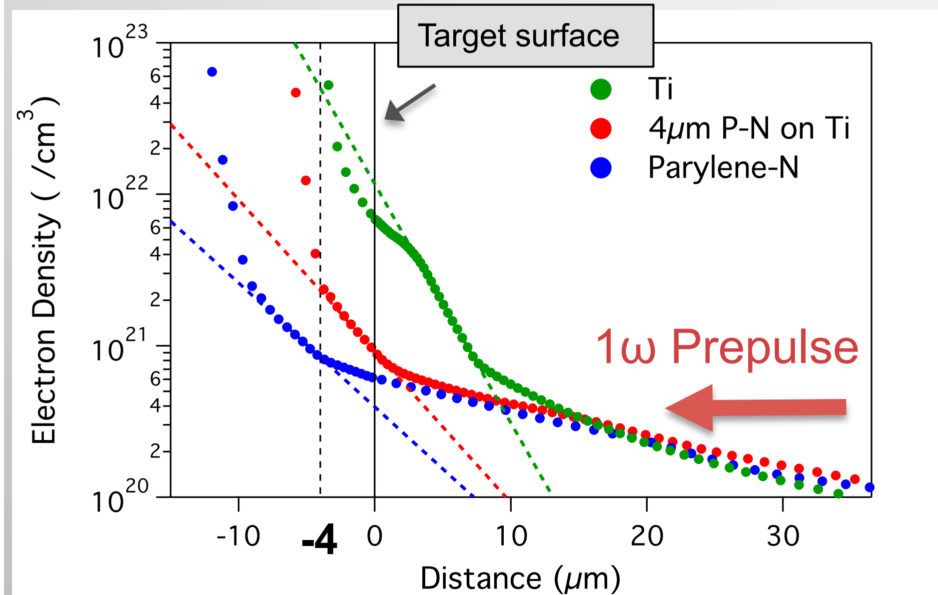
Line-out along the beam axis

HYDRA simulation ➔ high density regions

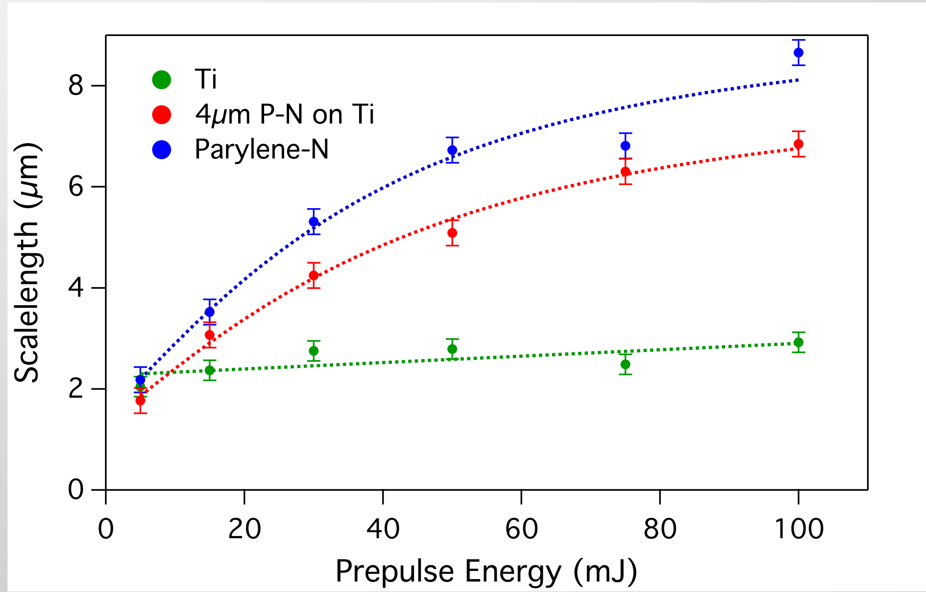
* Takeda et al. J. Opt. Soc. Am. Vol. 72, 156 (1982)
** C. J. Dasch, Applied Optics, Vol. 31, 1146 (1992)

HYDRA simulations were preformed to convert the prepulse energy (mJ) to scalelength (μm).

Target variation study



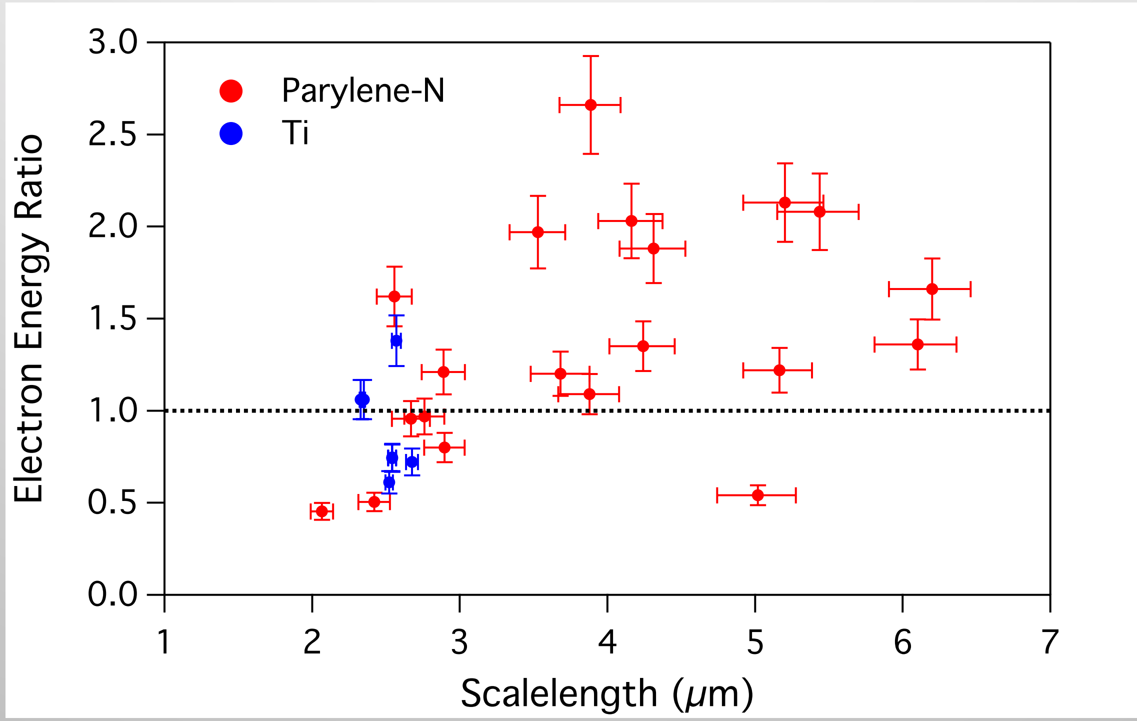
Prepulse energy study



Target	Fit to use
Solid Ti	**Ti**
3.7, 4.4 μm P-N coating	**4μm P-N on Ti**
15, 28 μm P-N coating Solid P-N	**Parylene-N**

Scalelength (μm) is a main contributing factor to the relativistic E-beam directionality.

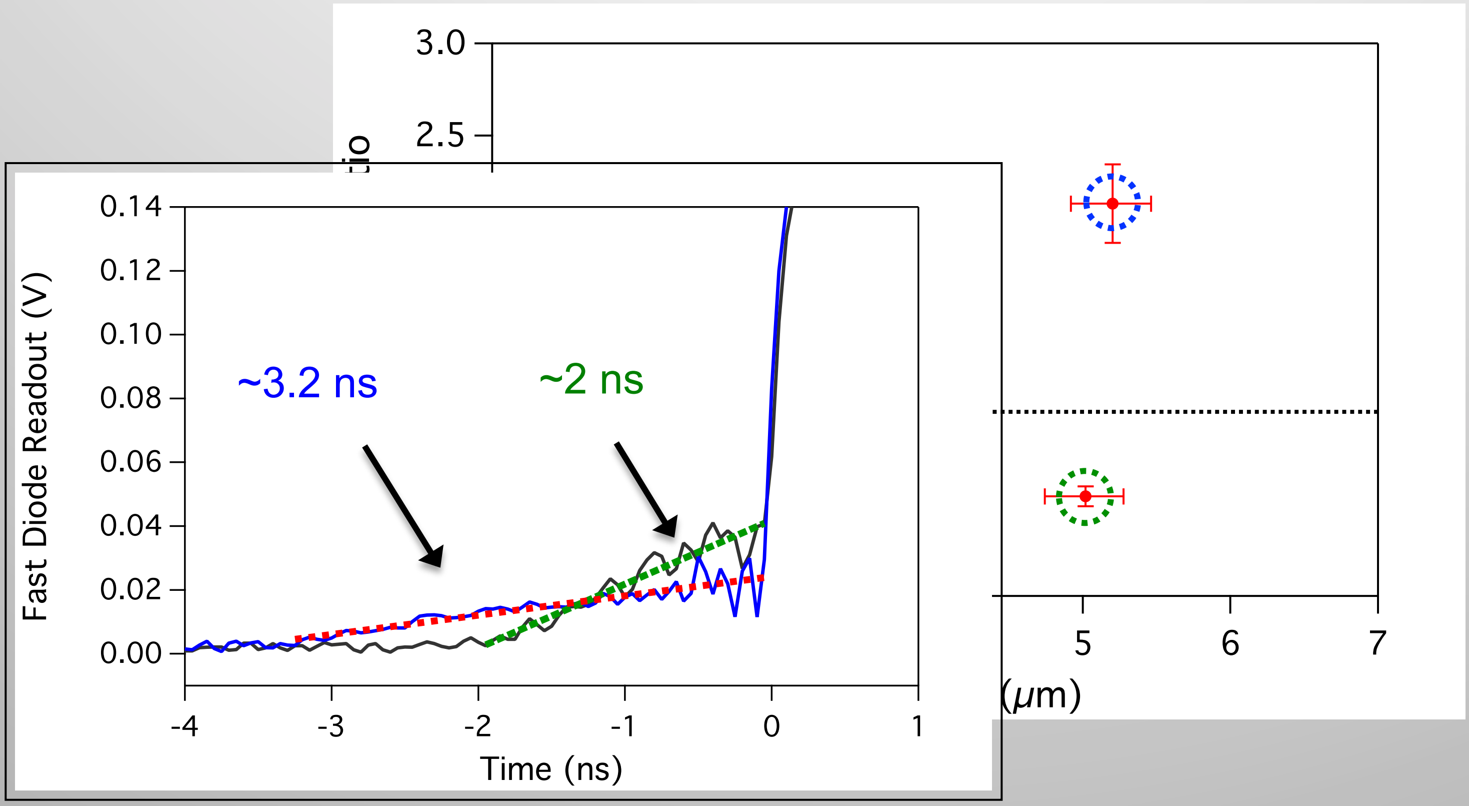
Electron Energy Ratio vs. Scalelength (μm)



Scalelength > 3~4 μm promotes directional E-beam along the SP laser.

Scalelength (μm) is a main contributing factor to the relativistic E-beam directionality.

Electron Energy Ratio vs. Scalelength (μm)



Prepulse Outlier ➔ Directionality Outlier

Summaries and Conclusion

- Electron Energy Ratio as an reliable Observable
- Strong Scalelength Effect on Relativistic E-beam Directionality
- Possible to control the relativistic E-beam direction